

State of California
AIR RESOURCES BOARD

EXECUTIVE ORDER D-155
Relating to Exemptions under Section 27156
of the Vehicle Code

LEGEND TURBO INC.'S
MODEL VW-34 TURBOCHARGER SYSTEM

Pursuant to the authority vested in the Air Resources Board by Section 27156 of the Vehicle Code; and

Pursuant to the authority vested in the undersigned by Sections 39515 and 39516 of the Health and Safety Code and Executive Order G-45-5;

IT IS ORDERED AND RESOLVED: That the installation of the Model VW-34 turbocharger system manufactured by Legend Turbo Inc. has been found not to reduce the effectiveness of required motor vehicle pollution control devices and, therefore, is exempt from the prohibitions of Section 27156 of the Vehicle Code for 1984 and 1985 model-year Volkswagen Jetta, Rabbit, and Scirocco models equipped with 1.8 liter fuel-injected engines.

This Executive Order is valid provided that installation instructions for this device will not recommend tuning the vehicle to specifications different from those submitted by the device manufacturer.

Changes made to the design or operating conditions of the device, as exempted by the Air Resources Board, that adversely affect the performance of a vehicle's pollution control system shall invalidate this Executive Order.

Marketing of this device using an identification other than that shown in this Executive Order or marketing of this device for an application other than those listed in this Executive Order shall be prohibited unless prior approval is obtained from the Air Resources Board. Exemption of a kit shall not be construed as an exemption to sell, offer for sale, or advertise any component of a kit as an individual device.

This Executive Order does not constitute any opinion as to the effect that the use of this device may have on any warranty either expressed or implied by the vehicle manufacturer.

THIS EXECUTIVE ORDER DOES NOT CONSTITUTE A CERTIFICATION, ACCREDITATION, APPROVAL, OR ANY OTHER TYPE OF ENDORSEMENT BY THE AIR RESOURCES BOARD OF ANY CLAIMS OF THE APPLICANT CONCERNING ANTI-POLLUTION BENEFITS OR ANY ALLEGED BENEFITS OF THE LEGEND TURBO INC.'S MODEL VW-34 TURBOCHARGER SYSTEM, WHICH IS EQUIPPED WITH A TURBOCHARGER THAT HAS AN A/R OF 0.59.

No claim of any kind, such as "Approved by Air Resources Board" may be made with respect to the action taken herein in any advertising or other oral or written communication.

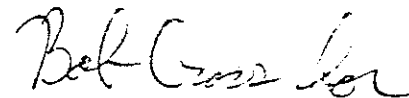
Section 17500 of the Business and Professions Code makes untrue or misleading advertising unlawful, and Section 17534 makes violation punishable as a misdemeanor.

Section 43644 of the Health and Safety Code provides as follows:

"43644. (a) No person shall install, sell, offer for sale, or advertise, or, except in an application to the state board for certification of a device, represent, any device as a motor vehicle pollution control device for use on any used motor vehicle unless that device has been certified by the state board. No person shall sell, offer for sale, advertise, or represent any motor vehicle pollution control device as a certified device which, in fact, is not a certified device. Any violation of this subdivision is a misdemeanor."

Any apparent violation of the conditions of this Executive Order will be submitted to the Attorney General of California for such action as he deems advisable.

Executed at El Monte, California, this 5th day of April, 1985.



K. D. Drachand, Chief
Mobile Source Division

State of California
AIR RESOURCES BOARD

EVALUATION OF LEGEND TURBO INC.'S MODEL VW-34 TURBOCHARGER SYSTEM FOR
EXEMPTION FROM THE PROHIBITIONS IN VEHICLE CODE SECTION 27156 IN ACCORDANCE
WITH SECTION 2222, TITLE 13, OF THE CALIFORNIA ADMINISTRATIVE CODE

April 1985

Date of Issue: April 1985

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EXEMPTION FROM THE PROHIBITIONS IN VEHICLE CODE SECTION 27156 IN ACCORDANCE
WITH SECTION 2222, TITLE 13, OF THE CALIFORNIA ADMINISTRATIVE CODE

by
Mobile Source Division

State of California
Air Resources Board
9528 Telstar Avenue
El Monte, CA 97131

(This report has been reviewed by the staff of the California Air Resources Board and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Air Resources Board, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.)

SUMMARY

MCD Associates, Inc. has requested an exemption from the prohibitions in Vehicle Code (V.C.) Section 27156 of the Legend Turbo Inc.'s (LTI) Model VW-34 turbocharger system for installation on 1984 and 1985 model-year Volkswagen Jetta, Rabbit and Scirocco models equipped with 1.8 liter fuel-injected engines.

The applicant submitted a comprehensive application package including comparative emissions test data, exhaust temperature study data, warranty statement, installation/maintenance procedures, and packaging/identification labels. The applicant also provided a test vehicle for confirmatory emissions tests.

Based on the submitted information and the results of exhaust emission tests performed by the applicant at an independent laboratory on a 1984 Volkswagen Jetta (49-State Certified), and of the confirmatory tests performed by another independent laboratory and the Air Resources Board's Haagen-Smit Laboratory on a 1984 VW Scirocco (California Certified), the staff concludes that the Legend Turbo Inc.'s Model VW-34 turbocharger system will not adversely affect exhaust emissions from the specified vehicles.

The staff recommends that LTI be granted a V.C. Section 27156 exemption as requested and that Executive Order D-155 be issued.

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I. INTRODUCTION

MCD Associates, Inc. of 3 Harbor Road, Cold Spring Harbor, New York 11724, has requested an exemption from the prohibitions in Vehicle Code (V.C.) Section 27156 for the Model VW-34 turbocharger system manufactured by Legend Turbo Inc. (LTI). The LTI Model VW-34 turbocharger system is intended for installation on 1984 and 1985 model-year Volkswagen Jetta, Rabbit and Scirocco models equipped with 1.8 liter, fuel-injected engines.

MCD Associates, Inc. submitted data from comparative (baseline vs. turbocharged) emission tests conducted on a 1984 Volkswagen Jetta GLI (49-state certified) equipped with a 1.8 liter, fuel-injected engine, at International Automotive Testing Laboratories, Inc., Hilltown Industrial Park, 861 Cath-Scott Road, Telford, PA 18969. Confirmatory tests were conducted on a 1984 VW Scirocco (California certified) at a second independent laboratory and also at the Air Resources Board (ARB) laboratory in El Monte, California.

II. CONCLUSION

Based on the submitted information and the results from comparative exhaust emission tests performed at an independent laboratory on a 1984 Jetta GLI, and from the confirmatory tests performed at a second independent laboratory and at the ARB on a 1984 Volkswagen Scirocco, the staff concludes that the Legend Turbo Inc.'s Model VW-34 turbocharger system will not adversely affect exhaust emissions from the specified vehicles.

III. RECOMMENDATION

The staff recommends that LTI be granted an exemption from the prohibitions in V.C. Section 27156 for the company's Model VW-34 turbocharger system for installation on 1984 and 1985 model-year Volkswagen Jetta, Rabbit, and Scirocco models equipped with 1.8 liter, fuel-injected engines. The staff also recommends that Executive Order No. D-155 be issued.

IV. LTI MODEL VW-34 TURBOCHARGER SYSTEM

The assembly of the LTI Model VW-34 turbocharger system is shown in Appendix A. The major components of the system are: exhaust manifold, a turbine, and a compressor. The original equipment manufacturers (OEM) exhaust manifold is replaced by the LTI exhaust manifold. The turbine inlet mounts directly to the exhaust manifold. The turbine, driven by exhaust gases, is linked to the compressor by a solid drive shaft. Intake air is routed from the air flow meter (sensor) to the compressor through the compressor inlet pipe. It is then compressed and routed into the intake plenum through the cross-over pipe. Exhaust gas from the turbine is sent to the catalytic converter via the exhaust downpipe.

Lubrication and cooling of the turbocharger bearings is provided by a fiber braided (special material impregnated) tube from a tap into the main oil galley. Lubricating oil from the turbocharger is returned to the oil pan.

Maximum positive pressure (boost) is limited to 7 psi by a wastegate internally mounted in the housing of the turbocharger. The wastegate control assembly rod is set during device installation so that the boost pressure cannot exceed 7 psi.

The heart of the LTI Model VW-34 turbocharger system is the Model RHB52 turbocharger, manufactured by Ishikawajima-Harima Heavy Industries, Inc. (IHI)

of Japan. This is a radial turbine type turbocharger, having a throat area (A) of 696 sq. mm (1.08 sq. in.), with a distance (R) of 46.4 mm (1.83 in.) from the centroid of the throat area to the center of the vortex and an A/R of 0.59.

The compressor used for this application carries the designation NR BRL 393 BZ. Appendix A-1 shows the applicable compressor map with the full load vehicle acceleration line included. This line is based upon the following: a) determination of the boost vs. rpm profile through experimental testing, and b) determination of the volumetric flow assuming an 85 percent engine volumetric efficiency through calculation.

Boost is regulated with an integral wastegate controlled by a conventional pressure sensing actuator assembly. Pressure build-up in the compressor outlet scroll acts on a diaphragm in the actuator assembly. Movement of the diaphragm, as a result of the applied pressure, is opposed by a calibrated spring. When the force exerted by the pressure exceeds that exerted by the spring, the diaphragm deflects, moving the linkage rod and opening the wastegate to relieve the pressure. Appendix A-2 shows the Control Assembly for RHB52 in detail.

An overboost protection feature has been incorporated into the OEM ignition system as shown in Appendix A-3. A normally closed, pressure actuated electrical switch opens when manifold pressure exceeds 8.0 psi, disrupting the 12 volt supply to the positive side of the coil. This de-energizes the ignition module which, in turn, de-energizes the fuel pump relay and fuel pump. Both ignition and fuel delivery are interrupted thus,

boost levels drop. This ignition system with overboost protection circuit is functionally identical to the overboost protection mechanism used by Chrysler Corporation on all their 1984 and 1985 model-year turbocharged vehicles. The system operates only when a mechanical failure results in manifold pressure which is so excessive that severe engine damage is likely to occur. The boost versus rpm profile at full load was established on the dynamometer. The dynamometer test results are shown in Appendix A-4.

Lubrication and cooling of the turbocharger bearings are effected by circulation of oil drawn from a location on the oil filter housing originally occupied by the "low engine oil pressure" warning light pressure switch. The switch is removed and a tee installed in its place. The switch is relocated to the vertical leg of the tee and the turbocharger oil supply line is connected to the horizontal leg of the tee. Oil drains out of the turbocharger by gravity through a steel upper drain tube, a short rubber hose and a steel lower drain tube into the oil pan.

The OEM fuel induction system and intake manifold were kept intact; no modifications were done to them. Air, coming from the air flow sensor, is routed directly to the throttle body in the OEM configuration. In the turbocharger configuration, inlet air is redirected, flowing from the air flow sensor exit to the turbocharger compressor inlet, through the compressor, and then from the compressor outlet to the throttle body. The air flow sensor exit to compressor inlet tube and the compressor outlet plenum are shown in Appendix A-5.

The static ignition timing is retarded three (3) degrees during turbocharger system installation. Ignition timing at idle is, therefore, changed from 6° BTDC to 3° BTDC.

Turbocharger installation requires modification to the OEM exhaust system between the exhaust parts and the catalyst inlet flange. Three new pieces are added:

a) Exhaust Manifold - It is modeled closely on the OEM manifold, only the outlet was changed in order to provide an outlet flange compatible with the turbocharger inlet flange. Nodular iron, rather than gray iron, is used because of its superior strength and resistance to high temperature.

b) Turbocharger Outlet Elbow - As the turbocharger outlet flange is extremely complex, the exhaust pipe cannot be mounted directly to the turbocharger. The cast outlet elbow (of nodular iron material) mates with the turbocharger and provides a viable exhaust pipe mounting flange. The oxygen sensor has been moved from the manifold to this elbow to avoid exposing the sensor to high exhaust manifold temperatures under boost conditions.

(c) Exhaust Header Pipe - The exhaust header pipe runs from the outlet elbow to the catalyst inlet flange and incorporates a corrugated, flexible section to absorb engine motion and vibration.

The valve train, EGR system, and catalytic converter are kept unchanged. The OEM air fuel mixture feedback control in the closed-loop operation is unaffected by turbocharger installation. The turbocharged engine requires that the system also operate open-loop at manifold pressures exceeding 0.75 psi. This is accomplished through the use of two (2) pressure actuated electrical switches. Switch #1 exposes pin #17 on the ECU to ground when manifold pressure rises above 0.75 psi. This causes the control system to operate the frequency valve at a fixed duty-cycle of 80% which is equivalent to the duty-cycle used in OEM open-loop mode. Switch #2, actuated at manifold pressures above 1.75 psi, drives the frequency valve to 100%

duty-cycle for improved performance and detonation suppression at high boost levels. Appendix A-6 shows the switch assembly in detail, including switch #3 used in the overboost protection circuit.

The OEM positive crankcase ventilation (PCV) system is unchanged except for the addition of the one-way check valve. This check valve is required to avoid pressurizing the crankcase during periods of positive manifold pressure.

V. EMISSION TEST DATA

A 1984 Volkswagen Jetta GLI (49-state certified) was used for testing by the applicant. A 1984 Volkswagen Scirocco (California certified) was used for confirmatory testing. The dynamometer equivalent inertia weight and road load horsepower used were 2500 lbs. and 8.0 hp, respectively.

The International Automotive Testing Laboratory (IATL) Inc. in Telford, PA conducted a set of comparative CVS-75 emissions tests on the VW Jetta GLI for the applicant.

The Automated Custom Systems (ACS) Inc. in Anaheim, CA performed CVS-75 tests on the VW Scirocco in the turbocharged configuration. The ARB conducted confirmatory tests on the same vehicle at the Haagen-Smit Laboratory in El Monte. A summary of the test results is tabulated as follows:

CVS-75 Test Results

1984 Volkswagen Jetta GLI (49-State Certified)

<u>Test Facility</u>	<u>Test Mode</u>	<u>Exhaust Emissions (gm/mi)</u>			<u>Fuel Economy (mpg)</u>
		<u>HC</u>	<u>CO</u>	<u>NOx</u>	
IATL	Turbocharged	0.21	1.94	0.14	--
IATL	Baseline	0.25	3.39	0.06	--

1984 Volkswagen Scirocco (California Certified)

<u>Test Facility</u>	<u>Test Mode</u>	<u>Exhaust Emissions (gm/mi)</u>			<u>Fuel Economy (mpg)</u>
		<u>HC</u>	<u>CO</u>	<u>NOx</u>	
ACS	Turbocharged	0.18	1.81	0.24	21.95
ARB	Turbocharged	0.18	2.34	0.16	23.89
1984 Volkswagen Emission Certification Values		0.21	1.60	0.10	
1984 California Emission Standards		0.41	7.00	0.70	

VI. DISCUSSION

A. TEST VEHICLE

The emission test results submitted by the MCD were obtained from a 49-state certified 1984 Volkswagen (VW) Jetta GLI.

The applicant claimed that the emission control systems performance of the following two 1984/1985 Volkswagen engine families:

EVW 1.8 V6FAF5 (49-state certified), and

EVW 1.8 V6FAC2 (California certified),

is equivalent. The applicant submitted comparative design data which show that the only difference between the two engine families is the presence of an air preheater unit, and an altitude compensated warm-up regulator on the 49-state vehicle/engine, while the California engine does not have these components. The staff verified the above information and requested the MCD to deliver a California certified vehicle, a 1984 VW Scirocco, for confirmatory testing.

B. EMISSIONS

The applicant submitted comparative emission test data of the LTI Model VW-34 turbocharger system. The comparative CVS-75 test results from the 1984 Volkswagen Jetta GLI included in the application package showed no significant

emission effects on the test vehicle with the turbocharger system installed. The difference of 0.08 g/mi in Nox emissions of the comparative test data between the baseline and turbocharged configuration is not considered to be significant by the staff.

Confirmatory CVS-75 emissions test data from the 1984 VW Scirocco showed emission levels well below the current 1984 and subsequent model-year California vehicle emission standards.

C. DURABILITY

1. Temperature Study

The applicant conducted a dynamometer temperature test program to study the change in exhaust temperatures due to the installation of the turbocharger. Testing began with the engine in the stock, normally aspirated condition and was completed after turbocharger installation. Four major areas of operation were examined:

- a. Part load, normally aspirated
- b. Full load, normally aspirated
- c. Part load, turbocharged
- d. Full load, turbocharged

The exhaust temperature test results indicate that the heat generated by the increased mass flow of fuel/air mixture in the turbocharged mode is converted to mechanical energy in passing through the turbine. The temperature drop across the turbine resulted in lower catalyst inlet and outlet temperatures. However, these lowered temperatures do not result in increased emissions as indicated by the emission test results. Lower catalyst inlet and outlet temperatures also indicate that the open-loop fuel enrichment calibration is operating properly and that the catalyst is functioning as designed.

2. Mileage Accumulation

The 1984 VW Jetta GLI was also used for durability study. The applicant used a road course for mileage accumulation. This course was intended to provide a means of accumulating mileage in a carefully monitored fashion, over a route encompassing both city and highway miles, at an average speed similar to that generated by the EPA's Durability Driving Schedule generally used in formal mileage accumulation. Four thousand (4000) miles were accumulated over the route prior to back-to-back emission testing. All mileage accumulation was performed with the turbocharger system installed. The subsequent emissions test results indicate that the turbocharger system functioned well after 4000 miles of operation.

Although the 2nd test vehicle, the 1984 VW Scirocco, did not have mileage accumulation with the turbocharger system installed before the back-to-back test, it is expected that its performance with mileage accumulation of 4000 miles would be very similar to that of the 1st test vehicle, the 1984 VW Jetta.

The staff reviewed the temperature curves submitted by the applicant and found that the catalyst inlet temperatures of the turbocharged engine are below those of the OEM engine. Therefore, any possibility of substrate meltdown or precious metal loss or migration from catalyst overheating are eliminated and the durability of the catalyst is assured.

D. WARRANTY

The applicant warrants the Legend Model VW-34 turbocharger system (System), including any component parts installed with the System, against defects in materials or workmanship for a period of twelve (12) months or twelve thousand (12,000) miles (whichever occurs first) from the date or

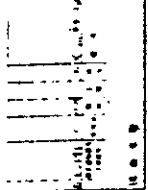
mileage when the System is installed on a vehicle, provided that the System is installed by an authorized LTI installer. This Warranty does not cover failures in the System which are the result of normal wear, accident, Acts of God, unauthorized modifications to the System, or maintenance or use of the vehicle or the System that is not in accordance with the manufacturer or by LTI. The Warranty extends to original and subsequent owners of the vehicle in which the System is installed.

E. EVALUATION

The applicant submitted a comprehensive application package including comparative emissions test data, exhaust temperature study data, warranty statement, installation/maintenance procedures, and packaging/identification labels. The applicant also provided a test vehicle for confirmatory emission tests. The staff evaluated the submitted information and the comparative emission data and found that the LTI Model VW-34 turbocharger system will not adversely affect exhaust emissions from the applicable vehicles and that the turbocharger system is in compliance with the requirements for exemption from the prohibitions in Vehicle Code Section 27156.

APPENDICES

10



HERNST 247

1. IDENTIFICATION DATA 1.1 NAME OF THE COMPANY 1.2 NAME OF THE PROJECT 1.3 NAME OF THE CLIENT 1.4 NAME OF THE DESIGNER 1.5 NAME OF THE CONTRACTOR		2. GENERAL DATA 2.1 DATE OF DESIGN 2.2 DATE OF CONSTRUCTION 2.3 DATE OF COMPLETION 2.4 DATE OF REVISION 2.5 DATE OF CANCELLATION		3. MATERIALS 3.1 MATERIAL 3.2 QUANTITY 3.3 UNIT 3.4 PRICE 3.5 TOTAL		4. MEASUREMENTS 4.1 MEASUREMENT 4.2 QUANTITY 4.3 UNIT 4.4 PRICE 4.5 TOTAL	
5. PARTS LIST 5.1 PARTS LIST 5.2 QUANTITY 5.3 UNIT 5.4 PRICE 5.5 TOTAL		6. GENERAL DATA 6.1 DATE OF DESIGN 6.2 DATE OF CONSTRUCTION 6.3 DATE OF COMPLETION 6.4 DATE OF REVISION 6.5 DATE OF CANCELLATION		7. MATERIALS 7.1 MATERIAL 7.2 QUANTITY 7.3 UNIT 7.4 PRICE 7.5 TOTAL		8. MEASUREMENTS 8.1 MEASUREMENT 8.2 QUANTITY 8.3 UNIT 8.4 PRICE 8.5 TOTAL	

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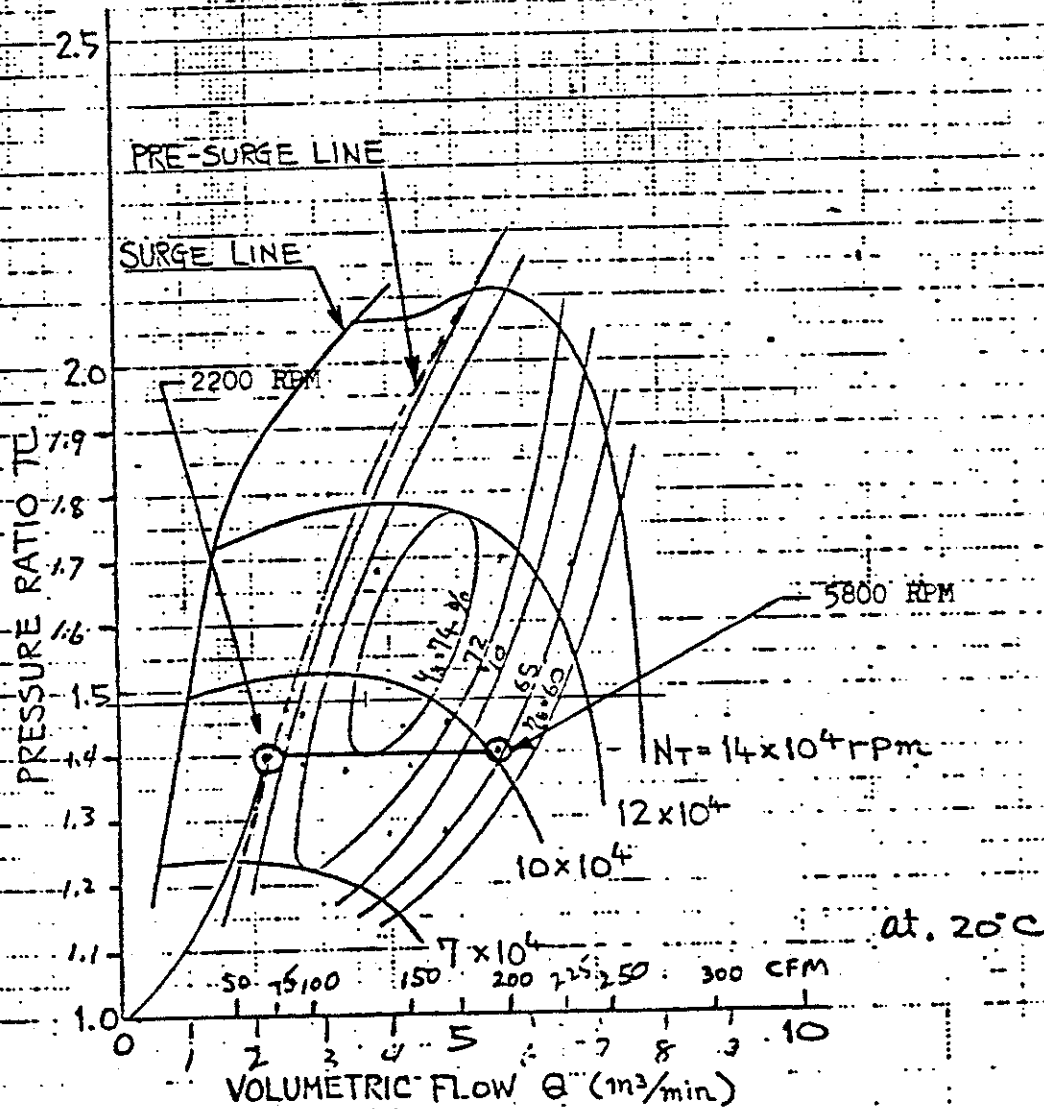
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IHI RHES TUREOCHARGER
COMPRESSOR MAPDRAWING No.
RR000744

COMPRESSOR SPEC. BRL393B

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3
3



CHIEF

M. Shimizu

Y. Bando

H. Honda

M. Shimizu

REV. 11 14 22

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REV. 11 11

NOV. 14, 1977

REV. 11 11

ADD DATA (TCW-6)

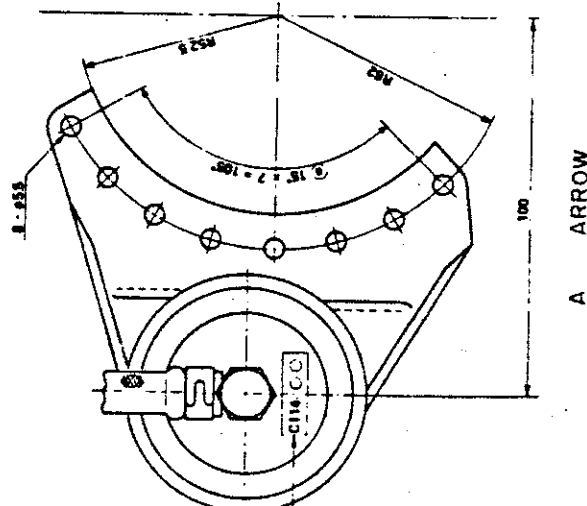
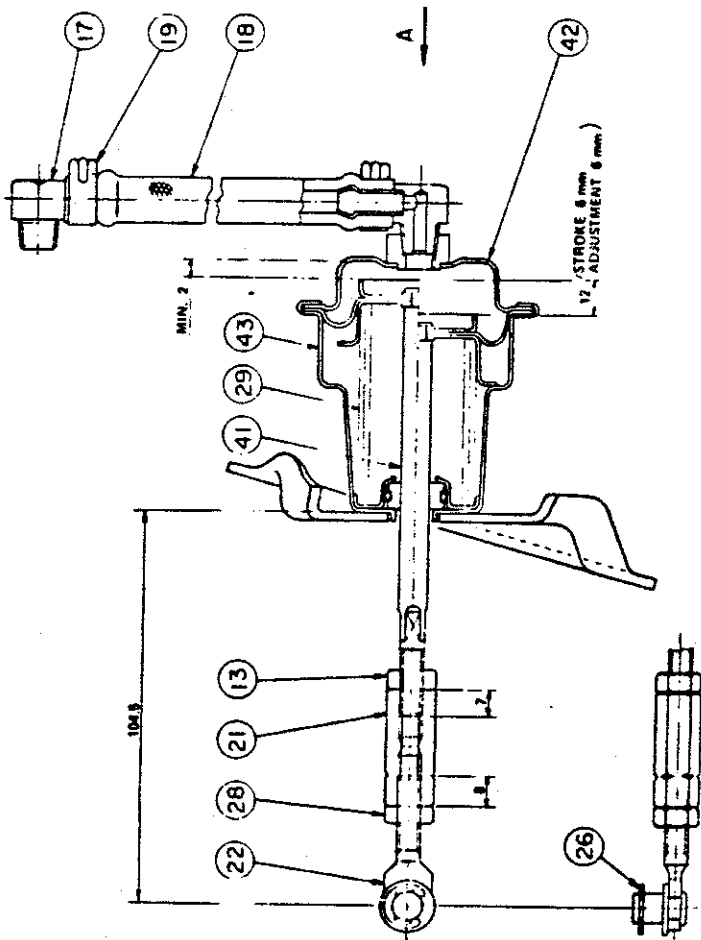
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SEP. 13, 1977

AM

APPENDIX A-2



SPECIFICATION OF ACTUATOR AND SPRING TO BE PRINTED AS FOLLOWS

Q114-00 SPEC. OF SPRING
Q114-00 SPEC. OF ACTUATOR

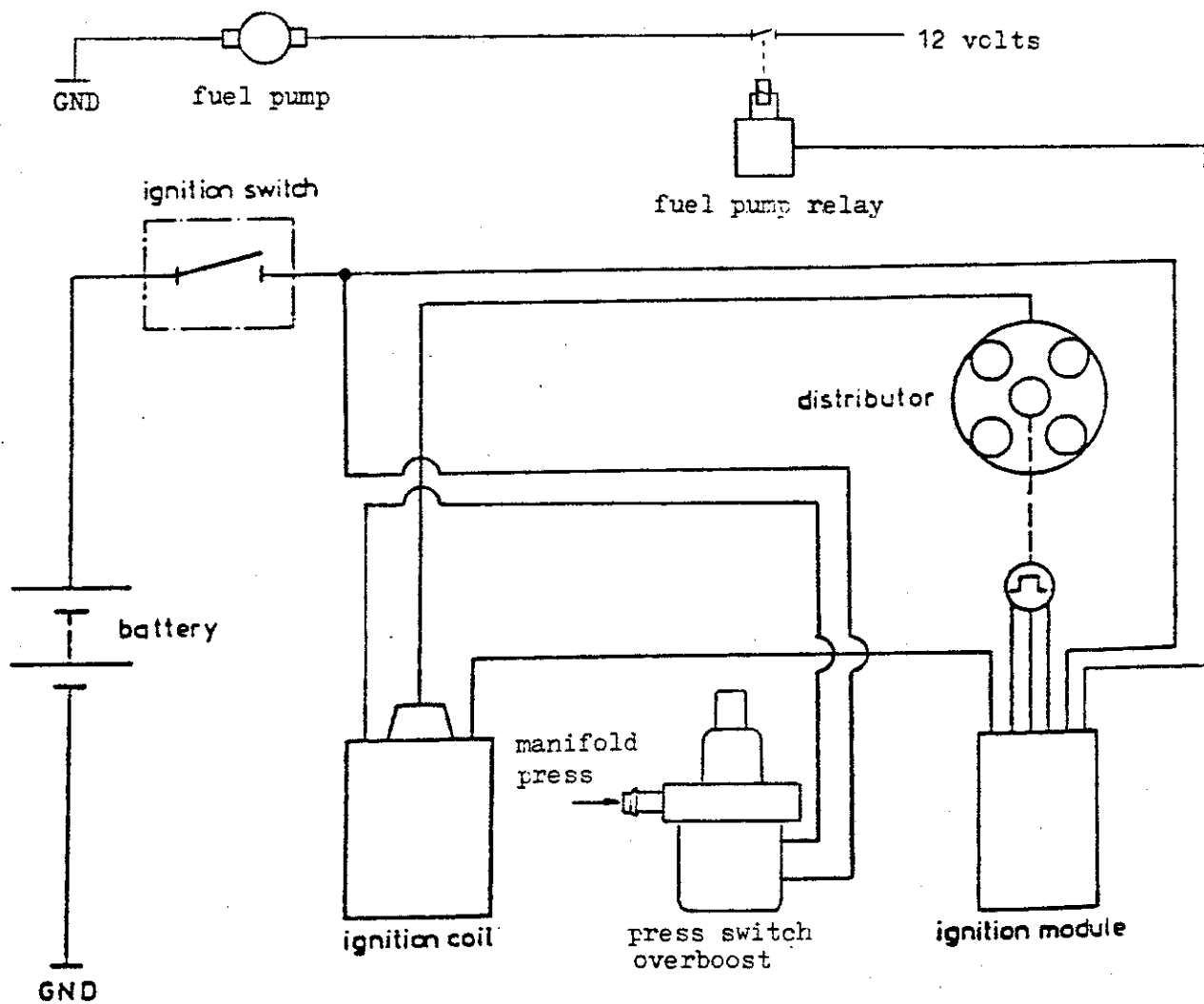
PRESSURE TEST
1 PRESSURE 1.2 kg/cm² G TO BE APPLIED AND SEALED.
2 PRESS RE IN ONE MINUTE TO BE MORE THAN 1.1 kg/cm² G.

NO	PARTICULARS
43	CUP ASSY (LOWER)
42	CUP ASSY (UPPER)
41	LINKAGE ROD ASSY
29	SPRING
28	NUT (LEFT HANDED)
26	RETAINING RING
22	LINK PIN
21	BOOST PRESS ADJUSTING NUT
19	CLIP
18	SENSING HOSE
17	MALE ELBOW
13	NUT
	PARTICULARS

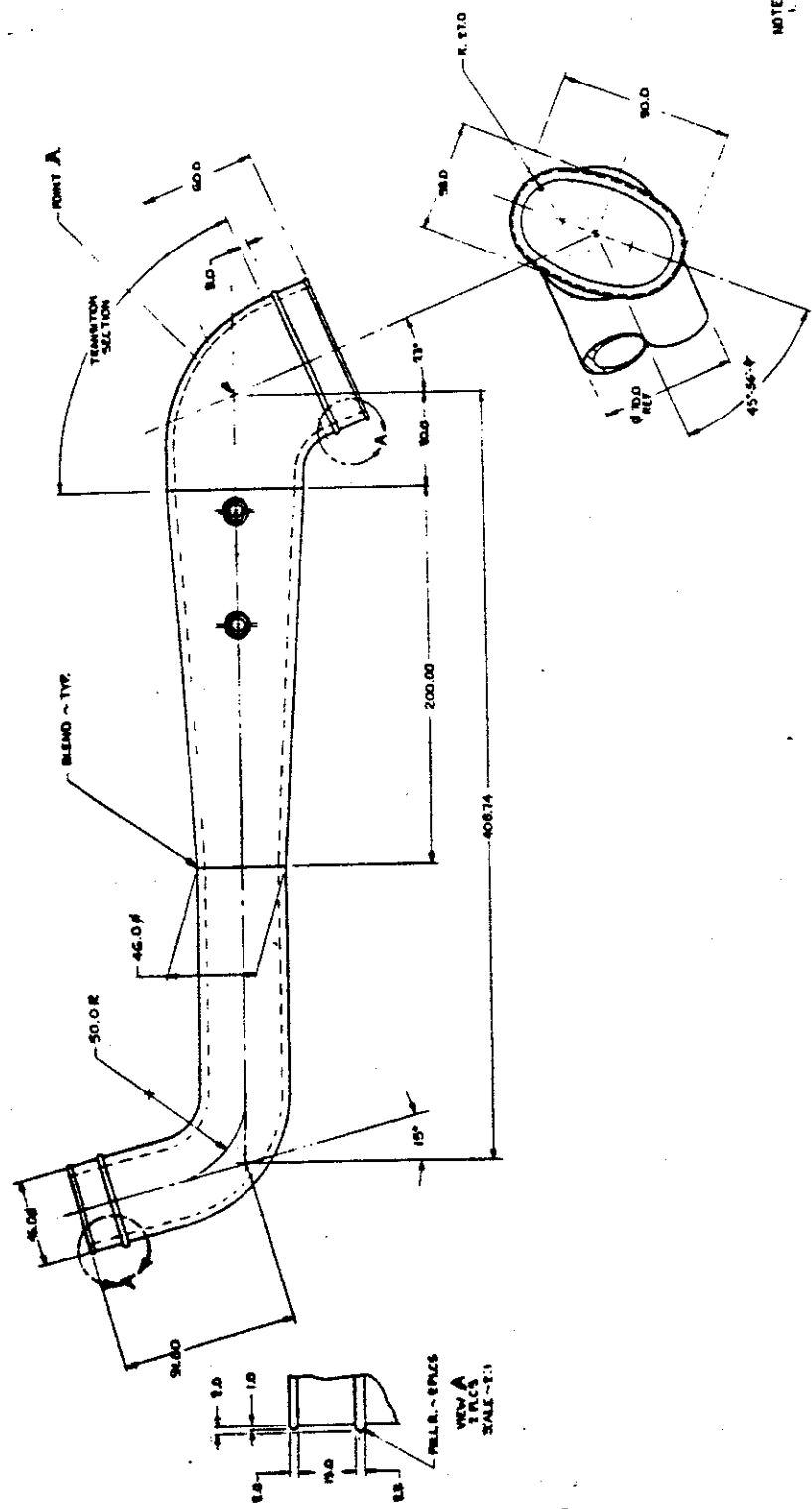
PARTICULARS		MATERIAL		REMARKS	
CONTROL ASSEMBLY FOR RH852					
SECTIONAL DRAWING				2 NN976015 2	
TYPE C-114					
ISHIKAWA K. K.		ISHIKAWA K. K.		ISHIKAWA K. K.	

APPENDIX A-3

Wiring Diagram For Ignition System
With Overboost Protection Circuit



DATE	10/10/88	BY	WJ
<p>MCD ASSOCIATES, INC.</p>			
<p>LINEAR 3.0.28 ANALOG SYSTEM</p>			
<p>DATE RECEIVED</p>			
<p>TITLE</p>			
<p>TUBE-COMPRESSOR INLET</p>			
DATE	10/10/88	BY	WJ
<p>MAN. 2.0000 and 2.0000</p>			
<p>MAN. 2.0000 and 2.0000</p>			



VIEW A
2 PLS